

What is claimed is:

1. A semiconductor device, comprising:
a wide bandgap semiconductor layer having an array of discontinuous wide
5 bandgap semiconductor regions therein that contribute to a reduction in ionization
energies of dopants in said wide bandgap semiconductor layer relative to an otherwise
equivalent wide bandgap semiconductor layer that is devoid of the array of
discontinuous wide bandgap semiconductor regions.
- 10 2. The device of Claim 1, wherein the array of discontinuous wide
bandgap semiconductor regions is a three-dimensional array.
3. The device of Claim 1, wherein said wide bandgap semiconductor
layer has a plurality of two-dimensional arrays of discontinuous wide bandgap
15 semiconductor regions therein that are parallel to each other.
4. The device of Claim 1, wherein the discontinuous wide bandgap
semiconductor regions in the array are nonuniformly spaced from each other.
- 20 5. The device of Claim 1, wherein the discontinuous wide bandgap
semiconductor regions in the array have nonuniform sizes and shapes.
6. The device of Claim 1, wherein said wide bandgap semiconductor
layer has a plurality of two-dimensional regular arrays of discontinuous wide bandgap
25 semiconductor regions therein that are parallel to each other.
7. The device of Claim 6, wherein the plurality of two-dimensional
regular arrays of discontinuous wide bandgap semiconductor regions are staggered
relative to each other.
- 30 8. The device of Claim 1, wherein said wide bandgap semiconductor
layer and the wide bandgap semiconductor regions are of net first conductivity type;
and wherein the wide bandgap semiconductor regions are more highly doped with
first conductivity type dopants relative to said wide bandgap semiconductor layer.

9 A semiconductor device, comprising:
a wide bandgap semiconductor layer having an array of discontinuous wide
bandgap semiconductor regions therein that have a wider bandgap relative to said
5 wide bandgap semiconductor layer.

10 10. The device of Claim 9, wherein the array of discontinuous wide
bandgap semiconductor regions is a three-dimensional array.

11 11. The device of Claim 9, wherein said wide bandgap semiconductor
layer has a plurality of two-dimensional arrays of discontinuous wide bandgap
semiconductor regions therein that are parallel to each other.

12 12. The device of Claim 9, wherein the discontinuous wide bandgap
15 semiconductor regions in the array are nonuniformly spaced from each other.

13 13. The device of Claim 9, wherein the discontinuous wide bandgap
semiconductor regions in the array have nonuniform sizes and shapes.

14 14. The device of Claim 9, wherein said wide bandgap semiconductor
layer has a plurality of two-dimensional regular arrays of discontinuous wide bandgap
semiconductor regions therein that are parallel to each other.

15 15. The device of Claim 14, wherein the plurality of two-dimensional
25 regular arrays of discontinuous wide bandgap semiconductor regions are staggered
relative to each other.

16 16. The device of Claim 9, wherein said wide bandgap semiconductor
layer and the wide bandgap semiconductor regions are of net first conductivity type;
30 and wherein the wide bandgap semiconductor regions are more highly doped with
first conductivity type dopants relative to said wide bandgap semiconductor layer.

17. A semiconductor device, comprising:
a Group III nitride layer comprising an array of discontinuous Group III
nitride regions therein that have a wider bandgap relative to said Group III nitride
5 layer.

18. The device of Claim 17, wherein the array of discontinuous Group III
nitride regions is a three-dimensional array.

10 19. The device of Claim 17, wherein said Group III nitride layer has a
plurality of two-dimensional arrays of discontinuous Group III nitride regions therein
that are parallel to each other.

20. The device of Claim 17, wherein the discontinuous Group III nitride
15 regions in the array are nonuniformly spaced from each other.

21. The device of Claim 17, wherein the discontinuous Group III nitride
regions in the array have nonuniform sizes and shapes.

20 22. The device of Claim 17, wherein said Group III nitride layer has a
plurality of two-dimensional regular arrays of discontinuous Group III nitride regions
therein that are parallel to each other.

23. The device of Claim 22, wherein the plurality of two-dimensional
25 regular arrays of discontinuous Group III nitride regions are staggered relative to each
other.

24. The device of Claim 17, wherein said Group III nitride layer and the
Group III nitride regions are of net first conductivity type; and wherein the Group III
30 nitride regions are more highly doped with first conductivity type dopants relative to
said Group III nitride layer.

25. The device of Claim 24, wherein said Group III nitride layer and the Group III nitride regions comprise different concentrations of the same constituent Group III elements.

5 26. The device of Claim 25, wherein said Group III nitride layer comprises $\text{Al}_w\text{In}_x\text{Ga}_{1-w-x}\text{N}$ and the Group III nitride regions comprise $\text{Al}_y\text{In}_z\text{Ga}_{1-y-z}\text{N}$.

 27. The device of Claim 17, wherein said Group III nitride layer and the Group III nitride regions comprise different concentrations of the same constituent
10 Group III elements.

 28. The device of Claim 27, wherein said Group III nitride layer comprises $\text{Al}_w\text{In}_x\text{Ga}_{1-w-x}\text{N}$ and the Group III nitride regions comprise $\text{Al}_y\text{In}_z\text{Ga}_{1-y-z}\text{N}$.

15 29. A semiconductor device, comprising:
 a wide bandgap semiconductor layer having an array of discontinuous wide bandgap semiconductor regions therein that have wider bandgaps relative to said wide bandgap semiconductor layer and are doped at sufficient levels to increase an electrical conductivity of said first wide bandgap semiconductor layer relative to an
20 otherwise equivalent wide bandgap semiconductor layer that is devoid of the array of discontinuous wide bandgap semiconductor regions.

 30. The device of Claim 29, wherein the array of discontinuous wide bandgap semiconductor regions is a three-dimensional array.

25

 31. The device of Claim 29, wherein said wide bandgap semiconductor layer has a plurality of two-dimensional arrays of discontinuous wide bandgap semiconductor regions therein that are parallel to each other.

30 32. The device of Claim 29, wherein the discontinuous wide bandgap semiconductor regions in the array are nonuniformly spaced from each other.

 33. The device of Claim 29, wherein the discontinuous wide bandgap semiconductor regions in the array have nonuniform sizes and shapes.

34. The device of Claim 29, wherein said wide bandgap semiconductor layer has a plurality of two-dimensional regular arrays of discontinuous wide bandgap semiconductor regions therein that are parallel to each other.

5

35. The device of Claim 34, wherein the plurality of two-dimensional regular arrays of discontinuous wide bandgap semiconductor regions are staggered relative to each other.

10

36. The device of Claim 29, wherein said wide bandgap semiconductor layer and the wide bandgap semiconductor regions are of net first conductivity type; and wherein the wide bandgap semiconductor regions are more highly doped with first conductivity type dopants relative to said wide bandgap semiconductor layer.

15

37. A method of forming a semiconductor device, comprising:
growing a wide bandgap semiconductor layer having an array of discontinuous wide bandgap semiconductor regions therein that have a wider bandgap relative to said wide bandgap semiconductor layer, using growth parameters that alternate between those that favor growth of the wide bandgap semiconductor layer and those that favor growth of the wide bandgap semiconductor regions for a duration
20 insufficient to support coalescing of the wide bandgap semiconductor regions.

38. A method of forming a semiconductor device, comprising:
growing a wide bandgap semiconductor layer of first material type having a
25 plurality of discontinuous wide bandgap semiconductor regions of second material type therein that have a wider bandgap relative to the wide bandgap semiconductor layer, by:

- (a) growing a wide bandgap layer of the first material type;
then
- 30 (b) growing a wide bandgap layer of the second material type on the wide bandgap layer of the first material type; then
- (c) patterning the wide bandgap layer of the second material type to define openings therein that expose portions of the wide bandgap layer of the first material type; and

(d) growing another layer of the wide bandgap layer of the first material type in the openings and on the patterned wide bandgap layer of the second material type; and
repeating steps (a), (b), (c) and (d) in sequence at least
5 once.

39. A semiconductor diode, comprising:

a first wide bandgap semiconductor layer of first conductivity type having a first plurality of discontinuous wide bandgap semiconductor regions of first
10 conductivity type therein that have a wider bandgap relative to said first wide bandgap semiconductor layer and contribute to an increase in conductivity of the first wide bandgap semiconductor layer by reducing an effective ionization energy of first conductivity type dopants therein; and

a second wide bandgap semiconductor layer of second conductivity type
15 having a second plurality of discontinuous wide bandgap semiconductor regions of second conductivity type therein that have a wider bandgap relative to said second wide bandgap semiconductor layer and contribute to an increase in conductivity of the second wide bandgap semiconductor layer by reducing an effective ionization energy of second conductivity type dopants therein.

20

40. The semiconductor diode of Claim 39, further comprising a third semiconductor layer extending between said first and second wide bandgap semiconductor layers, said third semiconductor layer comprising a material having a bandgap that is less than a bandgap of said first wide bandgap semiconductor layer
25 and less than a bandgap of said second wide bandgap semiconductor layer.